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Recovery and performance of the Noble Gas system at CLX19, Easter Island, during and after the COVID-19 pandemic lock-down

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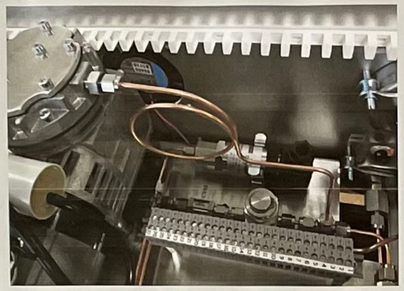
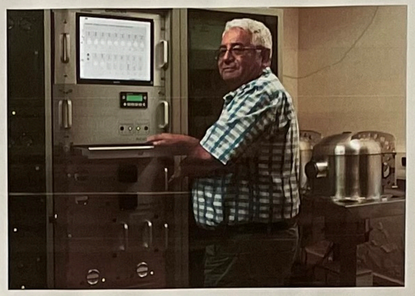
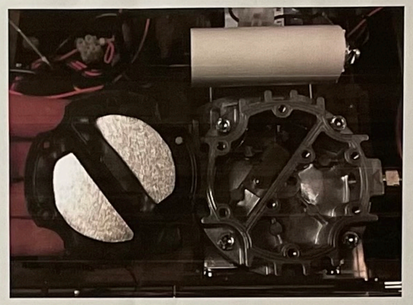
Introduction

The RN19 IMS station on Easter Island, Chile is equipped with a SAUNA xenon sampling system to monitor worldwide compliance with the CTBT. This SAUNA system had severe equipment failure shortly before the COVID-19 lockdown in 2020. Consequently, the system could not sample and measure Xenon.

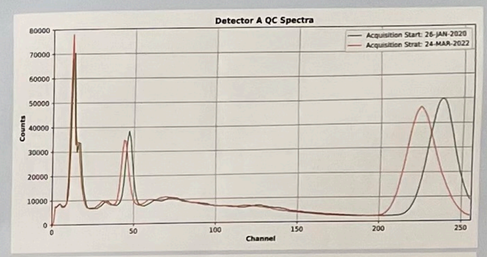
The lockdown for Easter Island made it impossible to visit the station and organize any repair or maintenance. Shipping of spare parts to the station was also heavily restricted. The system was non-operational for almost two years. When the possibility to ship spare parts resumed, it took several attempts and shipments of different spares before the station became operational again. The detector performance was questionable after the recovery of the system after more than 2 years of down time. A preventative maintenance visit was not possible before end of 2022, almost three years after the initial failure of the system.

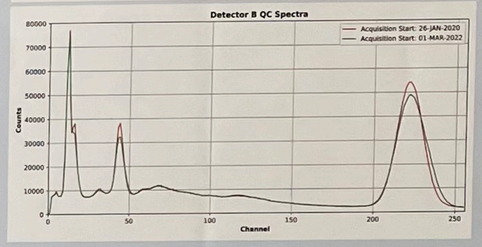






Detector performance





Without proper maintenance, the system was down for two years due to multiple issues in the system. Detector performance had to be evaluated before restoring the system back to normal operation. The evaluation process was challenging because adequate spectra were not available.

SAUNA II systems have QC sources for detector quality control, but it was noted that the geometry of the QC measurement had changed due to faulty QC source feeder, thus it was not a simple task to examine detector efficiency drops.

After in-depth discussions, it was concluded that gain drift, peak resolution and tailings could be investigated as a partial verification approach to confirm the integrity of detectors and electronics.

QC spectra from before and after the system-down were compared. The SAUNA QC source mix consists of Cs-137 and Eu-154. For gamma detectors, gamma peaks at 123.1 keV and 661.7 keV were investigated.

Incident history 2020-2022

The CLX19 SAUNA system on Easter Island, Chile stopped sending data on 28 January 2020. The system could not turn on detector high voltage and the sampling pumps stopped working. Remote troubleshooting was not sufficient to restore the system. Detector high voltage could be turned on again, but the sampling pumps did not run.

A preventative maintenance visit was scheduled for late March and additional time was added to this visit for troubleshooting and repair of the system.

The COVID-19 lock-down was enforced during March 2020. Travel was not possible to Easter Island for the preventative maintenance visit and repair of the system. Shipping of spare parts to the island was also not possible due to the COVID-19 lock-down.

Shipping of spare parts to Easter Island resumed in August 2020. Scienta prepared a new Sampling-Control-Unit for the station. It arrived in January 2021.

However, the detector high voltage problem had resumed and could not be solved. At the same time, a new problem had occurred. Even that air sampling had resumed, no xenon was separated in the system due to what seemed to be a problem with the gas chromatograph. Travel to the Easter Island was still not possible.

In July 2021, a new high voltage power supply, media converter, gas chromatograph and new hard drives for the computer was shipped to the station. Shipping was now faster. These new items could be installed in August 2021. Xenon was now extracted from the air sampled because of the new gas chromatograph. Unfortunately, the detector high voltage could still not be turned on, even that the new power supply and media converter was installed in the system.

After some more remote troubleshooting, a completely new computer for the sampling control (PHD computer) was shipped to the station. This new PHD computer arrived at the station in January 2022. After installation, the system now resumed normal operation after 2 years of down time.

After resuming normal operation, it was discovered that the quality control source was stuck in detector A. There was also a leak in the sampling system. Visit to the station was still not possible for non-Easter Island residents.

Remote troubleshooting and support helped to identify the leak to be in a control valve. The gasket of this valve was replaced by the local operators and the leak was reduced to an acceptable level.

In March 2022, the detector B of the system was enabled in normal operation again and the detector performance was verified by radionuclide analysts, based on comparison of data from previous data from the system. Detector A was enabled shortly after, now operating with manual inserted quality control source in this detector on a weekly basis.

Detector Performance Analysis

Detector	Energy [keV]	Acquisition Start	Centroid (H) Value	Centroid (H) Abs. Unc.	Sigma (σ) Value	Sigma (σ) Abs Unc	Low Tail (LT) Value	Low Tail (LT) Abs Unc	High Tail (HT) Value	High Tail (HT) Abs Unc
Det A	123.1	26-JAN-2020	47.16	0.01	2.10	0.02	3.70	0.41	2.95	0.20
		24-MAR-2022	44.50	0.03	2.08	0.05	3.69	1.31	2.01	0.18
	661.7	26-JAN-2020	237.56	0.04	8.46	0.07	12.54	0.43	5.96	0.22
		24-MAR-2022	224.38	0.23	9.75	0.55	9.72	1.69	6.38	0.38
Det B	123.1	26-JAN-2020	43.87	0.03	2.15	0.04	4.21	1.62	2.22	0.22
		01-MAR-2022	43.81	0.05	2.28	0.06	4.04	1.13	1.60	0.16
	661.7	26-JAN-2020	221.88	0.03	7.85	0.04	17.25	3.09	13.90	0.90
		01-MAR-2022	222.71	0.08	9.04	0.11	17.33	4.20	9.45	0.61

Linear Continuum Model

$f(x; a, b) = a + bx$

Gaussian Curve with High and Low Tails

$f(x; H, \mu, \sigma) = H\exp(\frac{-(x-\mu)^2}{2\sigma^2})$

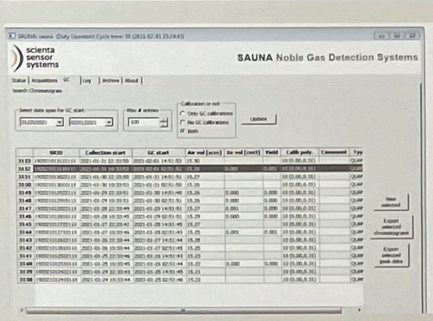
$f(x; H, \mu, \sigma, LT) = H\exp(\frac{LT(2x-2\mu+LT)}{2\sigma^2})$ where $x < (\mu - LT)$

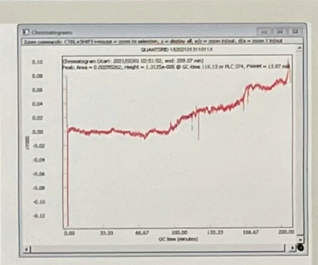
$f(x; H, \mu, \sigma, HT) = H\exp(\frac{HT(-2x+2\mu+HT)}{2\sigma^2})$ where $x > (\mu + HT)$

Non-linear least square fitting was performed with a linear continuum and a Gaussian curve with high- and low-tail terms. The results showed slight gain drifts. Resolution changes were also observed, however, the FWHMs snuggly satisfied the IDC operations criterion, which is the FWHM at 80 keV less than 16 keV. Comparable low- and high-tail terms suggested that peak shapes were not significantly deteriorated over the two years of down time.

The evaluation of beta detectors was performed using a calibration tool embedded in iNSPIRE because the QC source measurement does not provide enough statistics for the peak fitting method. It was also confirmed that beta detector systems showed reasonable performance for operational use.

Although a full system performance evaluation was not able to be conducted, the described analysis concluded that both detectors' performance was acceptable in comparison with that before the system down. They were then enabled in operation again. A detector calibration was requested to be included in the next preventative maintenance visit.





Outcomes and Conclusion

This case study shows a history of a station being down for a long time. It took several attempts of troubleshooting, preparation, shipping and installation of complete spare system parts to finally restore this system after two years of down time.

The main reason for the long period of down time was the COVID-19 lock down which not only delayed the possibility of sending a SAUNA system expert to this station, but also significantly delayed the shipment of spares to the station.

On the other hand, this case study is also an example of a great an excellent corporation of SAUNA system experts, station and local operators and PTS staff in restoring a complex system with a mix of remote support and on-site local hands.

It also shows the benefit of having a module design so each separate module can be replaced individually and somehow easily with minimum instructions and remote checkup and calibrations.